EFFECTS OF SOIL MOISTURE STRESS ON FOLIAR NUTRIENTS OF LOBLOLLY PINE

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ABSTRACT—Loblolly pine (*Pinus taeda* seedlings were subjected to three soil isture stresses during their second wing season. Foliar nitrogen was high- and foliar potassium, calcium, and gnesium were lower in those seedlings wn in the drier treatment. Foliar phos- orus was not affected by soil moisture ess.

Leaf analysis as a means of eval- ting the nutritive status of forest es has met with varying success. en where a correlation has been nd between nutrient concentra- ns in the leaf and in the soil, ere is always the question of how curately such data reflect the trient supplying power of a given e. Many variables, in addition to l fertility, affect the concentra- n of chemical elements in the f, such as physiological maturity, sition in tree, sampling date, time day sampled, and others (Leyton d Armson, 1955).

These reported studies and con- otions indicate that soil-moisture ess must play an important role the nutrient concentrations in e foliage. In an attempt to clarify ese findings and concepts, loblolly e seedlings were grown during eir second year in the greenhouse der varying soil-moisture stresses d the elements in the needles rrelated with soil moisture.

METHODS

The study consisted of two pha- s: The first phase was conducted th one-year-old loblolly pine seed- gs planted in pots filled with a t loam soil. This soil (Ap horizon) s developed from loess and is dium to high in K (.02 percent); v in P (trace), N (.01 percent), d organic matter (0.90 percent), and moderately to strongly acid (pH 5.2). The equivalent of 1,000 kilograms per hectare of a 12-12-12 (N, P, K) fertilizer was applied to each pot at planting time. The second phase of the study conducted the following year was with year-old seedlings grown from seed in pots (three seed per pot) filled with the same soil as used in the first phase but not fertilized. During both years, the soil with seedlings was allowed to dry until about 30 percent, 50 percent, or 70 percent of the available soil moisture was exhausted as determined by weighing, and then watered to above field capacity. Available moisture in this study is that moisture held in the soil between 1/3 and 15 bars as determined by the pressure pot and pressure membrane apparatus. There was 23 percent moisture in the soil at 1/3 bar and 8 percent moisture in the soil at 15 bars for this soil. Hereafter, these three soil-moisture levels will be known as low, medium, and high soil-moisture stresses, respectively.

Thirty seedlings were planted in individual pots in each of the three treatments in the first phase. Mortality reduced the number in the medium and high soil-moisture stress treatments to 18 and 8 seedlings, respectively. Twenty-five pots were used in each treatment in the second phase, but the number of seedlings per pot varied from one to three. At the termination of the second experiment, there were 44, 47, and 40 seedlings in the low, medium, and high soil-moisture stress treatments, respectively.

At the end of both growing sea-

sons, plants were removed from the pots and dried at 75° C. Foliar nitrogen was determined by a semimicro Kjeldahl procedure (Ranker, 1927), phosphorus by phosphomolybdic acid (A.O.A.C., 1945), potassium by flame emission, and calcium and magnesium by the EDTA method (Malmstadt and Hadjioannou, 1959).

Analysis of variance was made of the five elements in the needles with soil-moisture stresses.

Results

Shoot growth of seedlings du ing the study period varied by mo ture treatments. In both phases the study, seedlings subject to t drier conditions grew about 90 pe cent (as a percent of total heig at beginning of season), where those in the moist treatment (lo soil moisture stress) grew about 1 percent.

Table 1 shows the average n trient levels in the foliage under high fertility in the first phase. When the soil was supplied with adequate moisture (low moisture stress), the nitrogen content of the needles was significantly lower than in seedlings growing at higher soil-moisture stresses. At this relatively high soil fertility, soil moisture did not influence the concentration of phosphorus in the needles, but plants growing at low moisture stress had more potassium in the needles than plants growing und drier conditions.

Nutrient concentration in t needles are shown in Table 2 f the second phase. The results f N, P, and K were very similar those obtained in the first phas except that the concentrations N and P were much lower and higher. Calcium and magnesiu concentrations were higher at t low moisture stress than in t

TABLE 1. Foliar Nutrient Concentrations of Seedlings Grown under Different Moisture Stresses in the First Phase

Variable	Moisture stress		
	Low	Medium	Hi
	Percent of O.D. Weight		
N[1]	2.566	2.823	2.7
P	0.135	0.128	0.1
K[1]	0.280	0.241	0.2

[1]Low is significantly different from other stresses at 5 percent level.

TABLE 2. Average Foliar Concentrations and Ratios of Concentrations in Second Phase of Study

Variable	Moisture stress			F rat
	Low	Medium	High	
	Percent of O.D. weight			
N	0.862	1.093	1.118	16.3
P	0.072	0.078	0.071	1.8
K	0.319	0.301	0.290	3.4
Ca	0.286	0.266	0.264	4.0
Mg	0.231	0.208	0.204	12.4

[1]Significant differences between stresses at 1 percent level, 2.99.

gher stresses in this phase of the udy.

Discussion and Conclusions

The increase in foliar nitrogen the high moisture stress treat- ent probably means that when owth was limited by soil mois- re, nitrogen tends to accumulate thin the plant because the rate of try is approximately maintained conjunction with the decreased te of utilization in growth pro- sses. The general tendency for tassium, calcium, and magnesium be relatively low in plants on ier soil (high moisture stress) in- cates that the rates of entry into e plant of these elements are less an the rates of utilization in the w growing plants.

The increase in foliar potassium this study with decreasing soil oisture stress agrees with results tained for herbaceous plants and 26-year-old red pine growing on coarse sandy soil in New York ate (Jurgensen and Leaf, 1965). it the small difference in foliar tassium for the two years is diffi- lt to explain, as it was thought at the potassium contents of seed- gs grown in the well-fertilized il would be greater than they were.

It is well known that fertilizers teract with soil moisture stresses chomaker, 1969) and that the nu- ent concentration of plants grown different fertility levels may not ways conform to a set pattern. ese results tend to confirm the ought that many factors influ- ce an element in a plant, and it difficult to predict how any one ctor can affect the concentration an element within a plant.

It is recognized that the method ed in reporting the concentration nutrients in this paper (as a per- ntage of weight of oven-dry fo- ge) has its limitation, and there a possibility that some other method such as total uptake might be superior. This possibility has been suggested for red pine in western Massachusetts (Hoyle and Mader, 1964) and in the Adirondack region of New York (White and Leaf, 1965).

The most useful role that foliar analysis can play at the present time is in the nutrition of forest trees on depleted soils where nutrient deficiencies have been indicated. This technique has been used quite successfully in New York on potassium-deficient soils (Madgwick, 1964) and in Florida on phosphorus-deficient soils (Pritchett and Llewellyn, 1966).

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